

What is claimed is:

1. A fiber optic communication system comprising: an arrayed waveguide grating (AWG) that has N optical input ports (where N is an integer greater than or equal to 2) and N optical output ports, and that has a routing function that outputs to predetermined optical output ports in accordance with a wavelength of optical signals inputted to respective optical input ports, and M (where M is an integer no smaller than 2, nor greater than an integer N) network-node equipments connected via optical transmission paths so as to form a geometrically star-shaped physical star topology having the AWG

10 in the center,

wherein said network-node equipments comprise a device of wavelength switching that switches the wavelength of said optical signals in order to dynamically change a logical network topology that indicates a geometrical form of routes of the optical signals used for transmitting/receiving data (hereunder referred to as optical signals) between network-node equipments.

2. A fiber optic communication system according to claim 1, wherein said network-node equipments belong to at least one or more logical network topologies, and configure two or more mutually independent logical network topologies.

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3. A fiber optic communication system according to claim 1, wherein said wavelength switching device switches wavelengths of optical signals when connecting or transferring the network-node equipments belonging to a predetermined logical network topology, to another logical network topology.

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4. A fiber optic communication system according to claim 1, wherein a logical network topology is configured with two or more network-node equipments, and said wavelength switching device switches wavelengths of optical signals so that at a predetermined time, all of said two or more network-node equipments configure a new logical network topology that is different from said logical network topology.
5. A fiber optic communication system according to claim 1, wherein said logical network topology configures at least one kind of either: a ring-shaped logical network topology having geometrically a ring shape, a star-shaped logical network topology having a star shape, and a mesh-shaped logical network topology having a mesh shape, or configures a logical network topology that is a combination of these.
6. A fiber optic communication system according to any one of claims 1 to 5, wherein said wavelength switching device comprises a wavelength tunable light source unit capable of changing the wavelength of an output signal, and a wavelength tunable optical receiver unit capable of selecting the wavelength of a receiving optical signal; and said wavelength tunable light source unit comprises L (L being an integer no smaller than 2, nor greater than M) optical elements installed therein, said optical elements comprising an elemental structure in which a wavelength tunable laser and a modulator are connected in series or mutually integrated, or comprising a semiconductor laser diode with direct modulation capability, and being connected by an Lx1 optical coupler; and
- 20 said wavelength tunable optical receiver unit comprises L (L being an integer no smaller than 2, nor greater than M) optical elements installed therein, said optical elements comprising an optical receiver and a wavelength tunable filer connected in

series with the optical receiver and passing only a predetermined wavelength, and being connected to an Lx1 optical coupler.

7. A fiber optic communication system according to any one of claims 1 to 5,  
5 wherein said wavelength switching device comprises a wavelength tunable light source unit capable of changing the wavelength of an output signal, and a wavelength tunable optical receiver unit capable of selecting the wavelength of a receiving optical signal; and  
said wavelength tunable light source unit comprises L (L being an integer no smaller than 2, nor greater than M) optical elements installed therein, said optical  
10 elements comprising an elemental structure in which a wavelength tunable laser and a modular are connected in series or mutually integrated, or comprising a semiconductor laser diode with direct modulation capability, and being connected in series to LxN switches and Nx1 combiners which are connected in series, and  
said wavelength tunable optical receiver unit comprises L (L is an integer no  
15 smaller than 2, nor greater than M) optical receivers installed therein, said optical receivers being connected in series to the LxN switches and the Nx1 combiners.

8. A fiber optic communication system according to claim 6 or 7, wherein  
said network-node equipment comprises: L (L is an integer no smaller than 2, nor  
20 greater than M) optical signal in/output ports of network terminals that are connectable to network-terminal equipments, said optical signal in/output ports of network terminals comprising optical signal input ports of network terminals and optical signal output ports of network terminals;  
L O/E converters that convert optical signals from the L optical signal input ports  
25 of network terminals into electrical signals;

an E/O converter that converts into optical signals, output electrical signals from the L receivers that constitute said wavelength tunable optical receiver unit; and optical waveguides such as optical fibers by which output electrical signals from the L O/E converters are inputted to said wavelength tunable light source unit, and by 5 which the converted optical signals are outputted from the L optical signal output ports of network terminals.

9. A fiber optic communication system according to claim 6 or 7, wherein said network-node equipment comprises L (L being an integer no smaller than 2, nor greater than M) optical signal in/output ports of network terminals that are connectable to network-terminal equipments, said optical signal in/output ports of network terminals comprising optical signal input ports of network terminals and optical signal output ports of network terminals; and
- said L optical signal input ports of network terminals are connected in series to L 15 O/E converters which convert optical signals into electrical signals, and to 2Lx2L switches; and said L optical signal output ports of network terminals are connected in series to L E/O converters which convert electrical signals into optical signals, and to said 2Lx2L electrical switches; and furthermore said 2Lx2L electrical switches are connected to said wavelength tunable light source unit, and to said wavelength tunable 20 optical receiver unit; and by predetermined operation of said 2Lx2L electrical switches, optical signals delivered to said network-node equipment from said arrayed waveguide grating (AWG) are wavelength converted in said network-node equipment without being transmitted to network-node terminals that are physically connected to said network-node equipments, and are re-transmitted to said arrayed waveguide grating (AWG).

10. A fiber optic communication system according to any one of claims 1 to 9,

wherein

each of said network-node equipments and said arrayed waveguide grating comprise an optical circulator that changes the directions of input light signals and output  
5 light signals, and

input/output ports of the optical circulator provided for said network-node equipments are respectively connected to said wavelength tunable optical receiver unit and said wavelength tunable light source unit via optical waveguides such as optical fibers, and

10 input/output ports of the optical circulator provided for said arrayed waveguide grating (AWG) are respectively connected to an optical output port and an optical input port of the AWG, and

by respectively connecting common ports of the optical circulators provided for said network-node equipments and said AWG via optical waveguides such as single-core  
15 optical fibers,

each of the network-node equipments and the AWG are respectively connected via optical waveguides such as single-core optical fibers.

11. A fiber optic communication system according to any one of claims 1 to 10,

20 wherein said arrayed waveguide grating (AWG) has uniform-loss and cyclic-frequency (ULCF).

12. A fiber optic communication system according to any one of claims 1 to 11,

wherein said network-node equipment has two different wavelength paths connected to  
25 said arrayed waveguide grating (AWG), and a ring-shaped logical network topology is

formed as said logical network topology having two or more of said network-node equipments.

13. A fiber optic communication system according to claim 12, wherein each of said

5 network-node equipments that configure said ring-shaped logical network topology has two communication channels that allow backward communication,

and said device of wavelength switching, when one of the communication channels is disconnected, switches the wavelength of an optical signal so as to form a new ring-shaped logical network topology, so that the optical signal, which is inputted

10 from the other communication channel to be outputted to said one communication channel, is transmittable back to said the other communication channel.

14. A fiber optic communication system according to claim 12, wherein each of said network-node equipments belonging to said ring-shaped logical network topology has

15 two communication channels that allow backward communication, and

said device of wavelength switching, when communication with a network-node equipment that communicates using one communication channel fails, switches the wavelengths of an optical signal so as to configure a new ring-shaped logical network topology, so that the network-node equipment experiencing communication failure is bypassed, and communication with an arbitrary network-node equipment is established.

15. A fiber optic communication system according to any one of claims 1 to 14,

further comprising a central-management-equipment, and wherein

said central-management-equipment includes a controlling device that transmits

25 to said network-node equipment a control signal that includes information of changing

wavelength, and that receives a control signal that includes information of communication status from said network-node equipment, and

said device of wavelength switching of the network-node equipment switches the wavelength of an optical signal based on said control signal received from said central-management-equipment.

5 management-equipment.

16. A fiber optic communication system according to claim 15, wherein the wavelength of the control signal that is transmitted and received on each of said network-node equipments is set to be of a different wavelength bandwidth to that of said optical

10 signal, and

said network-node equipment comprises a WDM coupler having an optical combiner that combines said optical signal and the optical signal of said control signal, and an optical splitter that splits the combined signal of said optical signal and the optical signal of said control signal into said optical signal and the optical signal of said control

15 signal; and

said arrayed waveguide grating (AWG) comprises a WDM coupler having an optical combiner that combines the optical signal of the control signal from the central-management-equipment and the optical signal of the signal outputted from the arrayed waveguide grating (AWG), and an optical splitter that splits the combined signal of said 20 optical signal transmitted from each network-node and the optical signal of said control signal into said optical signal and the optical signal of said control signal, and the optical transmission path that said optical signal uses is also shared as an optical transmission path for said control signal.

17. A fiber optic communication system according to claim 15, wherein between said network-node equipment and said central-management-equipment, said control signal is transmitted physically separated from the communication channel that transmits said optical data signal.

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18. A fiber optic communication system according to claim 15, wherein said network-node equipment further comprises:

a node database that is provided in at least one of either inside or outside of the equipment and that stores wavelength data, and

10 a device of updating the data of said node database when the wavelength of said optical signal has been switched; and

said central-management-equipment further comprises a central database that is provided in at least one of either inside or outside of the equipment and that stores wavelength data of all of said network-node equipments, and

15 a device of updating the data of said central database when the wavelength used between said network-node equipments change.

19. A fiber optic communication system according to claim 18, wherein said network-node equipment has a device of storing in said node database information on: 20 available wavelength bandwidth, all wavelengths currently in use, transmitting optical power status and receiving optical power status of the optical signal of each wavelength, connection status between said network-node equipments, and logical network topology currently connected; and notifying said information to said central-management-equipment in response to a request therefrom.

20. A fiber optic communication system according to claim 18, wherein said network-node equipment has a device of always monitoring the transmitting optical power status and receiving optical power status of the optical signal of each wavelength, and detecting an abnormality and notifying said central-management-equipment, if an  
5 abnormality in these statuses occurs; and

said central-management-equipment comprises a device of detecting abnormality in the connection status between all of said network-node equipments, and the transmitting optical power status and receiving optical power status of the optical signal of each wavelength of said wavelength tunable light source unit, and of sharing the  
10 abnormal status information with all of said network-node equipments.

21. A fiber optic communication system according to claim 18, wherein said central-management-equipment comprises a device which,

when a control signal is received including a request for a network-node  
15 equipment currently connected to a logical network topology to change connection to another different logical network topology, determines whether or not to conform by querying said central database and performing a computation, and  
if the result of said determination is to conform,  
transmits a control signal including notification of disengagement and wavelength  
20 reconfiguration of said network-node equipment to all of said network-node equipments within the logical network topology to which the network-node equipment that launched said request of logical network topology connection change is connected, and  
transmits a control signal including notification of the joining of said network-node equipment and wavelength reconfiguration to all of the network-node equipments

within the logical network topology to which the network-node equipment that launched said request of logical network topology connection change, is to be connected.

22. A fiber optic communication system according to claim 18, wherein said central-  
5 management-equipment comprises at least one of either;
- a device which, when the amount of traffic between specific network-node equipments increases and a network load is generated, and a control signal including a request for a bandwidth increase between said network-node equipments is received, determines whether or not said request for a bandwidth increase is possible by querying  
10 said central database and performing a computation to form a new wavelength path, and transmits a control signal including notification of wavelength reconfiguration to set a rerouting wavelength path that is configured by routing through other network-node equipments to which said network-node equipment has not been connected, to each of the network-node equipments to perform setting of said rerouting wavelength path;  
15 or a device which, when the amount of traffic between specific network-node equipments increases and a network load is generated and a control signal including a request for a bandwidth increase between said network-node equipments is received, determines whether or not said request for a bandwidth increase is possible by querying said central database and performing a computation to form a new wavelength path, and  
20 transmits a control signal including notification of wavelength reconfiguration for providing a new rerouting wavelength path, by using a wavelength that has not been used by the network-node equipment connected to another logical network topology to which the said network-node equipment is not connected, to each of the network-node equipments to perform setting of said rerouting wavelength path.

23. A fiber optic communication system according to any one of claims 17 to 22,

wherein

    said network-node equipment further comprises:

    a device of synchronizing the clock time of each of the network-node equipments;

5 and

    a device of information-storing that stores new information of changing wavelength of the optical signals, and the information of reconfiguring time of the logical network topology including the time at which wavelength change should be executed, and

10       said device of wavelength switching switches the wavelengths of the optical signals at a predetermined time in accordance with said information of reconfiguring time of the logical network topology and said information of changing wavelength.

24. A fiber optic communication system according to any one of claims 17 to 23,

15 wherein

    said central-management-equipment further comprises a device of distributing clock time information that distributes clock time information to each of said network-node equipments;

20       said controlling unit comprises a device of generating new information of changing wavelength of the optical signals of each of said network-node equipments, and information of reconfiguring time of the logical network topology including the time the wavelength change should be executed, and transmitting them separately or all together to said network-node equipment;

    said network-node equipment comprises:

a device of adjusting clock time that adjusts its own clock time in accordance with the information of clock time distributed from said central-management-equipment, and

- a device of information-storing that receives and stores said information of  
5 changing wavelength and said information of reconfiguring time of the logical network topology transmitted from said central-management-equipment; and

said device of wavelength switching switches the wavelength of the optical signals at a predetermined time in accordance with said information of reconfiguring time of the logical network topology and said information of changing wavelength.

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25. A fiber optic communication system according to any one of claims 17 to 23, wherein

a specific network-node equipment among said network-node equipments comprises a device of distributing clock time information that distributes clock time  
15 information to other network-node equipments;

said other network-node equipments comprise a device of adjusting clock time that adjusts their own clock time in accordance with the clock time information distributed from said specific network-node equipment;

- 20 said specific network-node equipment comprises a device of generating information of changing wavelength of the optical signals of said network-node equipment, and information of reconfiguring time of the logical network topology including the time the wavelength change should be executed, and transmitting them separately or all together to said network-node equipments; and

25 said other network-node equipments comprise a device of information-storing that stores the information of changing wavelength and the information of reconfiguring

time of the logical network topology received from said specific network-node equipment; and

said device of wavelength switching of the other network-node equipments switches the wavelengths of the optical signals at a predetermined time in accordance  
5 with said information of reconfiguring time of the logical network topology and said information of changing wavelength.

26. A central-management-equipment that is connected to M (where M is an integer no smaller than 2, nor greater than an integer N) network-node equipments connected via

10 optical transmission paths and configured so as to form a geometrically star-shaped physical star topology having in the center an arrayed waveguide grating (AWG) that has N optical input ports (where N is an integer greater than or equal to 2) and N optical output ports and a routing function that outputs to predetermined optical output ports in accordance with a wavelength of optical signals inputted to respective optical input ports,

15 wherein said central-management-equipment comprises a device of controlling that transmits to said network-node equipments a control signal that includes information of changing wavelength of the optical signals and causes the switching of the wavelength of the optical signals, and receives from said network-node equipments a control signal that includes information of communication status, in order to dynamically change a  
20 logical network topology that indicates a geometrical form of routes of the optical signals used for transmitting/receiving data (hereunder referred to as optical signals) between said network-node equipments.

27. A network-node equipment that is connected to M (M is an integer greater than or

25 equal to 1 and less than or equal to N-1) other network-node equipments via an arrayed

waveguide grating (AWG) that has N (N is an integer greater than or equal to 2) optical input ports and N optical output ports and a routing function that outputs to predetermined optical output ports in accordance with a wavelength of optical signals inputted to respective optical input ports, comprising:

- 5        a device of synchronizing clock time that synchronizes the clock time of each of the other network-node equipments,
  - a device of information-storing that stores new information of changing wavelength of optical signals, for dynamically changing a logical network topology that indicates a geometrical form of routes of the optical signals used for
- 10      transmitting/receiving data between other network-node equipments (hereunder referred to as optical signals), and information of reconfiguring time of the logical network topology that includes the time at which changing wavelength should be executed; and
  - a device of wavelength switching that switches a wavelength of the optical signals in accordance with said information of changing wavelength and said information of reconfiguring time of the logical network topology.
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